PROPOSAL 9-98

MS IN ENVIRONMENTAL ENGINEERING SCIENCE

Michigan Technological University will award the MS in Environmental Engineering Science as described below.

Synopsis

The Department of Civil and Environmental Engineering presently offers an MS degree in Environmental Engineering. Students are admitted to that program from both engineering and non-engineering disciplines, but must complete the requirements for a first degree in engineering as part of their MS plan of study if they do not possess a BS in engineering. Here we propose establishment of the MS in Environmental Engineering Science as a complement to the existing degree program. The proposed program would not impose fulfillment of the requirements for a first degree in engineering as a necessary criterion for graduation. However, students enrolled in this program will take a majority of their courses in engineering and their Advisory Committee will consider an understanding of engineering principles to be a necessary component of the "general professional knowledge" covered in the oral examination.

Introduction

Environmental engineering, as defined by the American Academy of Environmental Engineers, involves

"the application of engineering principles to improve and maintain the environment for the protection of human health, for the protection of nature's beneficial ecosystems, and for the environment-related enhancement of the quality of human life." [1]

The scope of this definition reflects the evolution of the field from its beginnings in water supply and wastewater treatment to the present day involvement in a wide range of issues in the air, water, and soil environments. With this growth, has come a need to broaden the competency of practitioners beyond the traditional confines of civil engineering, integrating the skills, insight, and vision of those from allied disciplines. The potential for contribution to the field of environmental engineering by those in other fields was recognized by those who developed the PhD in Environmental Engineering at Michigan Tech. That degree program welcomes those

"holding a degree in either mathematics, the natural or physical sciences, or engineering."[2]

The proposed MS in Environmental Engineering Science would extend this recognition to the MS level, offering those holding the baccalaureate in allied fields an opportunity to study environmental engineering. The proposal would, at the same time, affirm the value of the existing MS in Environmental Engineering for those who seek to be licensed as professional engineers. The proposed MS in Environmental Engineering Science would also serve to strengthen the PhD program in Environmental Engineering, attracting a more diverse body of students to the MTU campus and providing a new source of candidates for that advanced degree.

Motivation

The environmental engineering profession has grown dramatically over the past decade, providing a wealth of employment opportunities for our graduates. In 1997, the University Career Center placed 97%

of the BS graduates utilizing their service. The track record is as good or better for recipients of the MS in Environmental Engineering, most of whom are placed well before completion of the program. Within the field of environmental engineering, there exists a need both for licensed professional engineers and for scientists who can bring the key principles attributable to their discipline to bear in the solution and prevention of environmental problems. In order to attract top flight students from the sciences to the field of environmental engineering, it is necessary to offer a program of graduate study tailored to their needs.

The current degree program, the MS in Environmental Engineering, requires that applicants holding non-engineering degrees take collateral coursework to meet ABET guidelines for a first degree in engineering. This is interpreted to mean that, including both the BS and MS programs, the student must complete collateral coursework equivalent to at least one year of engineering science (48 quarter credits), one-half year of engineering design (24 quarter credits), and one year of basic mathematics and science (48 quarter credits). Although appropriate for applicants seeking to be licensed as professional engineers, this requirement has proven to be a significant barrier in recruiting students with degrees in allied fields, i.e. environmental science, natural and physical sciences. The proposed MS in Environmental Engineering Science would offer our faculty a means of attracting talented students from allied fields. This alternative is seen as critical to the development of research programs in air, soil, and water quality - areas where students with first degrees in biology, chemistry, geology, and physics are especially well qualified. The proposed degree program accomplishes the goals of attracting additional students and promoting research programs in the environmental sciences, while affirming the value of the existing MS in Environmental Engineering for those seeking to be licensed. In identifying the degree as one in Engineering Science, the proposal also supports the 'truth in labeling' position of the American Academy of Environmental Engineers.

Precedent

At Michigan Tech, the Departments of Mechanical Engineering - Engineering Mechanics (MS in Engineering Mechanics) and Geological Sciences and Engineering (MS in Geology and MS in Geophysics) offer 'non-engineering' degrees in traditionally engineering-oriented programs. The need to accommodate students with non-engineering degrees applying for study in engineering departments is widely recognized on other campuses as well. A variety of approaches has been utilized, ranging from an absolute requirement for collateral coursework prior to accrual of graduate credit (Wayne State University), through a recommendation for collateral coursework with no fixed criteria (Michigan State University), to a complete waiver of collateral coursework (University of Michigan). Others have established parallel degree programs targeted for the non-engineer. More than twenty-five schools which offer the MS in Civil and/or Environmental Engineering also offer an MS program comparable in spirit to the proposed MS in Environmental Engineering Science (Table 1). As noted in this table, a wide variety of program titles have been devised to convey the character of the various courses of study. The proposed program would utilize the title Environmental Engineering Science, recognizing the intent of recipients to apply their knowledge of environmental science and their understanding of engineering applications in the solution of interdisciplinary problems requiring collaboration between scientists and engineers. The title would further distinguish the course of study from that leading to licensure and more narrowly define the program focus vis-à-vis the less-specific 'environmental science' - a course of study offered at various universities in departments as diverse as biology, civil engineering, forestry, and public health.

Table 1. Universities with degree programs comparable to that proposed [3,4].

MS Environmental Engineering Science	Caltech, Florida, Illinois, Syracuse
MS Environmental Science	Alberta, Carnegie Mellon, Central Florida, Cincinnati, Drexel, Florida Institute of Technology, Kansas, New Jersey Institute of Technology, Oklahoma, Rice, SUNY-Buffalo
MS Environmental Quality Science	Alaska-Fairbanks
MS Environmental	Colorado School of Mines, Rice, Virginia Tech

Science and Engineering	
MS Environmental Pollution Control/Systems	Central Florida, Penn State
MS Environmental/Public Health Science	Kansas, North Carolina, RPI, Tufts
MS Applied Science	Delaware
MS or MA Undesignated	Clarkson, Georgia Tech, Johns Hopkins, McGill

Relationship to Other Programs

The proposed program is consistent with the University's emphasis on environmental education as embodied in the MTU Initiative for the Environment and supports the stated University goal of increasing graduate student enrollment. The proposed program would attract students from the natural and physical sciences seeking to utilize their talents in environmental engineering applications. These students would be drawn not only from a national and international population, but also from baccalaureate programs in the environmental sciences offered at Michigan Tech, e.g. Ecology and Microbiology (Biological Sciences), Environmental Chemistry (Chemistry), Applied Ecology and Environmental Science (Forestry), Environmental Geology (Geological Engineering and Sciences). In doing so, the proposed program fills an open niche which has led students toward competing programs at other universities. The proposed program would serve to improve the diversity of academic experience of our graduate

student population and increase enrollment in graduate classes, both in environmental engineering and in the natural, physical and social sciences. Table 2 considers the proposed program within the framework of degrees presently available in the Department of Civil and Environmental Engineering at Michigan Tech.

Table 2. Comparison of degree programs.

Degree Program	Target
MS Civil Engineering	A research degree for students with a first degree in engineering seeking to practice as licensed professionals in one or more of the traditional civil engineering disciplines, e.g. structures, transportation, geotechnical, and construction. The program of study includes a report or thesis.
MS Environmental Engineering	A research degree for students with a first degree in engineering, seeking to practice as licensed professionals in environmental engineering. The program of study includes a report or thesis.
M.E. (Environmental Engineering)	A terminal professional degree, leading to licensure, for students with a first degree in engineering. The program of study focuses on coursework and a design practicum.
MS Environmental Engineering Science	A research degree for students with a first degree in the sciences, not seeking licensure as professional engineers. The program of study includes a report or thesis.

Budgetary Issues

There will be no start-up costs for this program; the faculty, laboratories, equipment, and program framework already exist within the Department. The basic and supporting coursework relating to the proposed degree are presently available within the Civil and Environmental Engineering and allied departments (see example programs below).

Admission Requirements

Admission requirements will be identical to those for the existing MS in Environmental Engineering.

Advisory Committee

Like the current MS programs in Civil and Environmental Engineering and consistent with MTU Graduate School policies, a faculty Advisor would be assigned by the department chair, based on the recommendation of the faculty and in consultation with the student. With the assistance of the Advisor, the student will assemble an Advisory Committee, the composition of which is subject to approval by the department chair.

Degree Requirements

The primary focus of the MS in Environmental Engineering Science is the integration of environmental science, mathematics, and engineering application. Each student must take forty-five (45) credits. Plan A (Thesis) and Plan B (Report) will be options for the MS in Environmental Engineering Science. It is anticipated that most applicants will choose the thesis option, however, the report alternative is proposed here to provide flexibility.

Plan A -- Thesis Option

In addition to a minimum of

30 credits of coursework and

9-15 credits of thesis research, for a

45 credit minimum total

this plan requires a research thesis, supervised by the Advisor, which describes a research investigation and its results.

Coursework credit distribution must be

at least 18 credits must be from 500-600 level courses and

no more than 18 credits may be at the 300-400 level

Plan B - Report Option

Of the 45 total credit minimum, at least 36 must be earned in coursework other than the project.

36-42 credits of coursework and

3-9 credits of project report, for a

45 credit minimum total

this plan requires an independent project, supervised by the Advisor, which describes a research investigation and its results.

at least 18 credits must be from 500-600 level courses and

no more than 18 credits may be at the 300-400 level

Due to the interdisciplinary nature of environmental engineering, there are no structured course requirements. Instead, each MS student, under the guidance of the Advisory Committee, will tailor an academic plan of mutual interest and benefit, drawing a majority of the coursework from engineering departments.

The general requirements will be under the control of the Advisory Committee to ensure that the student's coursework addresses the basic criteria of educational programs for environmental engineers as defined by AAEE. Specifically, the program of study will provide exposure to,

"the dependence of mankind on a healthy environment; the conception, design and operation of engineered systems affording protection of human health and the environment; the interactions and transformations that occur across environmental media (i.e. surface water, groundwater, land, and air); the behavior of natural systems in response to outside stimuli caused by man's activities; and the need to work closely and effectively with other professionals in multi-disciplinary teams to meet the challenge of environmental protection." [5]

The Advisory Committee will consider an understanding of engineering principles to be a necessary component of the "general professional knowledge" covered in the oral examination.

In addition to the general requirements, each student must declare an emphasis area for focused study. Again, with consultation of the Advisory Committee, a sequential development of coursework will be selected to increase the depth of exposure to one of the following major focus areas of environmental engineering:

Surface water quality and water resources

Environmental systems modeling

Pollution prevention

Environmental chemistry

Wastewater

Solid waste and hazardous wastes

Atmospheric systems and air pollution control

Groundwater and subsurface remediation

Additional coursework will be selected to increase the breadth of exposure to other focus areas in environmental engineering, consistent with the student's stated career objectives.

Sample Degree Courses

Ample course offerings are available each quarter, as environmental engineering courses offered by the Department of Civil and Environmental Engineering faculty are evenly distributed throughout the year. At the 500-level, four are offered in the Fall, four are offered in the Winter, and three are offered in the Spring Quarter. At the 400-level, seven are offered in the Fall, four are offered in the Winter, and seven are offered in the Spring Quarter. Pre-requisites for these courses can generally be met through CE352 (Environmental Engineering) and the basic science and math coursework typically taken by students in the natural and physical sciences. It is expected, given their academic background in the sciences, that students in the proposed program would draw the majority of their coursework from the basic engineering coursework options presented in Table 3a. Supporting coursework (Table 3b), could also be taken, as approved by the Advisory Committee. The coursework listings in Table 3 are open to amendment as the university curriculum and the proposed program evolve. Examples of potential programs of study, focusing on specialty areas within environmental engineering, are outlined in Table 4.

Oral Examination or Defense

Examination by and approval of the Advisory Committee is required for awarding the Master of Science in Environmental Engineering Science. The Advisory Committee will examine the general professional knowledge, coursework, and in Plans A and B, the thesis or report of each master's candidate. An oral presentation of the thesis or report will be made following the completion of the written work. Copies of the thesis or report are to be distributed to the Advisory Committee at least two weeks prior to the examination data. The thesis, report, or coursework examination is acceptable if the Advisor and at least

two of the other three Advisory Committee members concur on its acceptance. The oral presentation for the thesis or report is open to the public.

References

[1] American Academy of Environmental Engineers, *AAEE Environmental Engineering Program Criteria Draft*, February 3, 1996, p. 1.

[2] Michigan Technological University, *Graduate School Bulletin*, 1996-98, p. 29.

[3] Association of Environmental Engineering Professors, *Register of Environmental Engineering Graduate Programs*, 7th Edition, 1993.

[4] American Society for Engineering Education, *Directory of Graduate Engineering Statistics*, 1995-96.

[5] American Academy of Environmental Engineers, *AAEE Environmental Engineering Program Criteria Draft*, February 3, 1996, p. 1.

Table 3a. Basic Engineering Coursework Options	**Table 3b. Supporting Coursework Options**
CE 402 Environmental Engineering Design Project (All, 3 cr.) All	BL 404 Environmental Biochemistry I (W, 3 cr.) Adler, Lueking
CE 450 Drinking Water Treatment (F, 3 cr.) Hand	BL 405 Environmental Biochemistry II (S, 3 cr.) Lueking, Adler
CE 451 Wastewater Treatment Engineering (W, 3 cr.) Hand	BL 421 Environmental Microbiology (W, 4 cr.) Bagley
CE 452 Water Chemistry (F, S, 4 cr.) Mihelcic, Urban, Perlinger	BL 445 Limnology (F, 4 cr.) Keen
CE 453 Surface Water Quality Engineering (F, 3 cr.) Auer	BL 546 Advanced Ecology - Ecosystems (W, 3 cr.) Kerfoot
CE 454 Water Distribution - Wastewater Collection (W, 3 cr.) Johnson	CM 498 Environmental Chemical Engineering (W, 3 cr.) Shonnard
CE 455 Solid and Hazardous Waste Management (F, 3 cr.) Mihelcic	CM 501 Molecular Transport (F, 3 cr.) Morrison
CE 456 Hazardous Waste Treatment (S, 3 cr.) Hand	CM 502 Turbulent Transport (S, 3 cr.) Morrison
CE 457 Solid and Hazardous Waste Containment (S, 3 cr.) Vitton	CM 535 Advanced Chemical Engineering Kinetics I (W, 3 cr.) Rogers
CE 458 Air Quality Engineering (W, 3 cr.) Honrath	CM 536 Catalysis and Reactivity of Solids (W, 3 cr.) Mullins
CE 459 Atmospheric Physics and Chemistry (S, 3 cr.) Paterson	FW 555 GIS for Resource Management (W, 4 cr.) Maclean
CE 463 Hydrology (F, S 3 cr.) Santeford	FW 422 Wetlands Management (F, 4 cr.) Gale, Shetron
CE 467 Open Channel Hydraulics (F, 3 cr.) Santeford	FW 554 Remote Sensing of the Environment (F, 4 cr.) Maclean
CE 468 Water Resources Engineering (S, 3 cr.) Santeford	GE 406 Introduction to Meteorology (S, 3 cr.)
CE 504 Environmental Organic Chemistry I (W, 3 cr.) Perlinger/Green	GE 425 Global Change and Earth Systems (W, 4 cr.) Rose, Bluth
CE 505 Environmental Organic Chemistry II (S, 3 cr.) Perlinger/Green	GE 470 Applied Geoscience Data Analysis (W, 3 cr.) Bornhorst
CE 506 Biogeochemistry (S, 3 cr.) Urban	

CE 550 Air Quality Modeling (W, 3 cr.) Paterson CE 553 Environmental Process Engineering (F, 4 cr.) Crittenden CE 554 Biological Treatment Processes (W, 4 cr.) Baillod CE 555 Water Quality Modeling (W, 3 cr.) Auer CE 556 Physical and Chemical Treatment (S, 4 cr.) Crittenden CE 557 Groundwater Quality Modeling (F, 3 cr.) Gierke CE 558 Atmospheric Chemistry (F, 3 cr.) Honrath CE 559 Fate in Soil & Groundwater (F, 3 cr.) Mihelcic GE 421 Hydrogeology (F, 3 cr.) Mayer GE 493 Site Investigation (W, 3 cr.) Mayer GE 494 Groundwater Engineering (S, 3 cr.) Gierke GE 594 Transport in Porous Media (W, 3 cr.) Gierke GE 595 Mathematical Modeling of Earth Systems (S, 3 cr.) Mayer CM/GE 496 Subsurface Remediation (F, 3 cr.) Gierke, Mayer, Shonnard	GE 551 Geophysical Applications of Remote Sensing (S, 3 cr.) Rose MA 430 Numerical Analysis (F, W, S, Su, 4 cr.) Hicks ME 474 Fuels and Combustion (F, 3 cr.) Cho SS 478 Environmental Politics (W, 3 cr.) Maclennan SS 547 Global Environmental Systems (F, 4 cr.) Baltensperger SS 548 Human Dimensions of Environment (W, 3 cr.) Halvorsen SS 549 International Politics of the Environment (W, 3 cr.) Durfee SS 551 Environmental Decision Making I (F, 2 cr.) Durfee SS 552 Environmental Decision Making II (W, 2 cr.) Durfee SS 553 Environmental Decision Making III (S, 3 cr.) Durfee SS 577 U.S. Environmental Policy (F, 3 cr.) Solomon SS 578 Environmental Policy Analysis (S, 3 cr.) Solomon

Table 4a. Surface water quality and water resources	**Table 4b. Groundwater and subsurface remediation**
BL 445 Limnology (F, 4 cr.) Keen BL 546 Advanced Ecology-Ecosystems (W, 3 cr.) Kerfoot CE 450 Drinking Water Treatment (F, 3 cr.) Hand CE 452 Water Chemistry (F, S, 4 cr.) Mihelcic, Urban, Perlinger CE 453 Surface Water Quality Engineering (F, 3 cr.) Auer CE 463 Hydrology (F, S 3 cr.) Santeford CE 468 Water Resources Engineering (S, 3 cr.) Santeford CE 504 Environmental Organic Chemistry I (W, 3 cr.) Perlinger CE 505 Environmental Organic Chemistry II (S, 3 cr.) Perlinger CE 506 Biogeochemistry (S, 3 cr.) Urban CE 555 Water Quality Modeling (W, 3 cr.) Auer CE 553 Environmental Process Engineering (F, 4 cr.) Crittenden	CE 450 Drinking Water Treatment (F, 3 cr.) Hand CE 451 Wastewater Treatment Engineering (W, 3 cr.) Hand CE 452 Water Chemistry (F, S, 4 cr.) Mihelcic, Urban, Perlinger CE 557 Groundwater Quality Modeling (F, 3 cr.) Gierke CE 559 Fate in Soil & Groundwater (F, 3 cr.) Mihelcic CM/GE 496 Fundamentals of Subsurface Remediation (F, 3 cr.) Gierke et al CM/CE 497 Subsurface Remediation Laboratory (W,S 3 cr.) Shonnard et al. CM 498 Environmental Chemical Engineering (W, 3 cr.) Shonnard GE 421 Hydrogeology (F, 3 cr.) Mayer GE 493 Site Investigation (W, 3 cr.) Mayer GE 494 Groundwater Engineering (S, 3 cr.) Gierke GE 594 Transport in Porous Media (W, 3 cr.) Gierke GE 595 Mathematical Modeling of Earth Systems (S, 3 cr.) Mayer

CE 556 Physical and Chemical Treatment (S, 4 cr.) Crittenden FW 422 Wetlands Management (F, 4 cr.) Gale, Shetron FW 555 GIS for Resource Management (W, 4 cr.) Maclean	

Table 4c. Environmental systems modeling	**Table 4d. Pollution prevention**
CE 506 Biogeochemistry (S, 3 cr.) Urban	
CE 550 Air Quality Modeling (W, 3 cr.) Paterson	CE 452 Water Chemistry (F, S, 4 cr.) Mihelcic, Urban, Perlinger
CE 555 Water Quality Modeling (W, 3 cr.) Auer	CE 459 Atmospheric Physics and Chemistry (S, 3 cr.) Paterson
CE 553 Environmental Process Engineering (F, 4 cr.) Crittenden	CE 506 Biogeochemistry (S, 3 cr.) Urban
CE 554 Biological Treatment Processes (W, 4 cr.) Baillod	CE 550 Air Quality Modeling (W, 3 cr.) Paterson
CE 557 Groundwater Quality Modeling (F, 3 cr.) Gierke	CE 553 Environmental Process Engineering (F, 4 cr.) Crittenden
CE 559 Fate in Soil & Groundwater (F, 3 cr.) Mihelcic	CE 555 Water Quality Modeling (W, 3 cr.) Auer
GE 595 Mathematical Modeling of Earth Systems (S, 3 cr.) Mayer	CE 558 Atmospheric Chemistry (F, 3 cr.) Honrath
FW 554 Remote Sensing of the Environment (F, 4 cr.) Maclean	CE 559 Fate in Soil & Groundwater (F, 3 cr.) Mihelcic
GE 470 Applied Geoscience Data Analysis (W, 3 cr.) Bornhorst	CM 498 Environmental Chemical Engineering (W, 3 cr.) Shonnard
MA 430 Numerical Analysis (F, W, S, Su, 4 cr.) Hicks	GE421 Hydrogeology (F, 3 cr.) Mayer

Table 4e. Solid and hazardous wastes	**Table 4f. Atmospheric systems and air pollution control**
BL 404 Environmental Biochemistry I (W, 3 cr.) Adler, Lueking	
BL 421 Environmental Microbiology (W, 4 cr.) Bagley	CE 452 Water Chemistry (F, S, 4 cr.) Mihelcic, Urban, Perlinger
CE 452 Water Chemistry (F, S, 4 cr.) Mihelcic, Urban, Perlinger	CE 458 Air Quality Engineering (W, 3 cr.) Honrath
CE 455 Solid and Hazardous Waste Management (F, 3 cr.) Mihelcic	CE 459 Atmospheric Physics and Chemistry (S, 3 cr.) Paterson
CE 456 Hazardous Waste Treatment (S, 3 cr.) Hand	CE 506 Biogeochemistry (S, 3 cr.) Urban
CE 457 Solid and Hazardous Waste Containment (S, 3 cr.) Vitton	CE 550 Air Quality Modeling (W, 3 cr.) Paterson
CE 504 Environmental Organic Chemistry I (W, 3 cr.) Perlinger	CE 553 Environmental Process Engineering (F, 4 cr.) Crittenden
CE 505 Environmental Organic Chemistry II (S, 3 cr.) Perlinger	CE 556 Physical and Chemical Treatment (S, 4 cr.) Crittenden
	CE 558 Advanced Atmospheric Chemistry (F, 3 cr.) Honrath

CE 554 Biological Treatment Processes (W, 4 cr.) Baillod CE 557 Groundwater Quality Modeling (F, 3 cr.) Gierke CE 559 Fate in Soil & Groundwater (F, 3 cr.) Mihelcic GE 421 Hydrogeology (F, 3 cr.) Mayer GE 493 Site Investigation (W, 3 cr.) Mayer	GE 406 Introduction to Meteorology (S, 3 cr.) Kostinski GE 425 Global Change and Earth Systems (W, 4 cr.) Rose, Bluth GE 470 Applied Geoscience Data Analysis (W, 3 cr.) Bornhorst GE 551 Geophysical Applications of Remote Sensing (S, 3 cr.) Rose

Table 4g. Wastewater	**Table 4h. Environmental chemistry**
BL 404 Environmental Biochemistry I (W, 3 cr.) Adler, Lueking BL 405 Environmental Biochemistry II (S, 3 cr.) Lueking, Adler BL 421 Environmental Microbiology (W, 4 cr.) Bagley CE 451 Wastewater Treatment Engineering (W, 3 cr.) Hand CE 452 Water Chemistry (F, S, 4 cr.) Mihelcic, Urban, Perlinger CE 504 Environmental Organic Chemistry I (W, 3 cr.) Perlinger CE 505 Environmental Organic Chemistry II (S, 3 cr.) Perlinger CE 553 Environmental Process Engineering (F, 4 cr.) Crittenden CE 554 Biological Treatment Processes (W, 4 cr.) Baillod CE 556 Physical and Chemical Treatment (S, 4 cr.) Crittenden CM 535 Advanced Chemical Engineering Kinetics I (W, 3 cr.) Rogers	BL 404 Environmental Biochemistry I (W, 3 cr.) Adler, Lueking BL 405 Environmental Biochemistry II (S, 3 cr.) Lueking, Adler CE 450 Drinking Water Treatment (F, 3 cr.) Hand CE 452 Water Chemistry (F, S, 4 cr.) Mihelcic, Urban, Perlinger CE 458 Atmospheric Chemistry and Physics (S, 3 cr.) Paterson CE 504 Environmental Organic Chemistry I (W, 3 cr.) Perlinger CE 505 Environmental Organic Chemistry II (S, 3 cr.) Perlinger CE 506 Biogeochemistry (S, 3 cr.) Urban CE 553 Environmental Process Engineering (F, 4 cr.) Crittenden CE 558 Atmospheric Chemistry (F, 3 cr.) Honrath

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